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(54) **PEN-SIZE LED INSPECTION LAMP FOR DETECTION OF FLUORESCENT MATERIAL**

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(52) **U.S. Cl.** ..... **362/184**; 362/198; 362/230; 362/800; 250/504 H
(58) **Field of Search** ..... 362/184, 186, 362/198, 138, 230, 293, 118, 119, 800; 250/504 H

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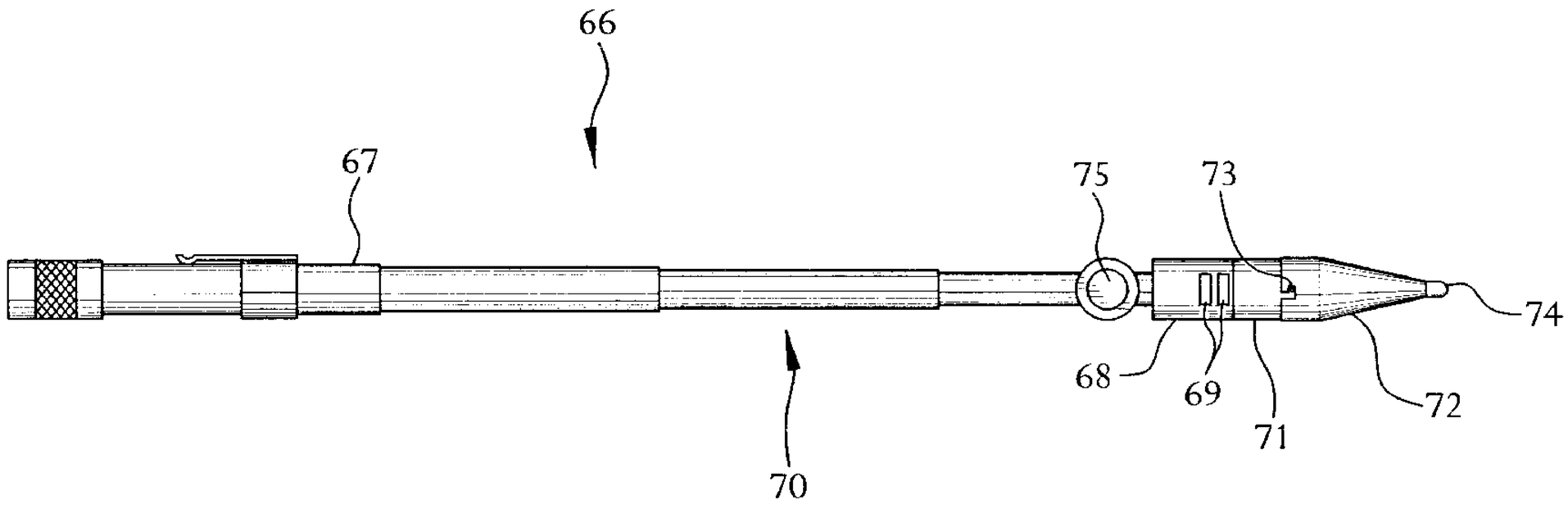
(57) **ABSTRACT**

A pen-size inspection lamp for detecting fluorescent materials. The inspection lamp includes a lamp housing, an extendible handle, and at least one LED.

29 Claims, 8 Drawing Sheets



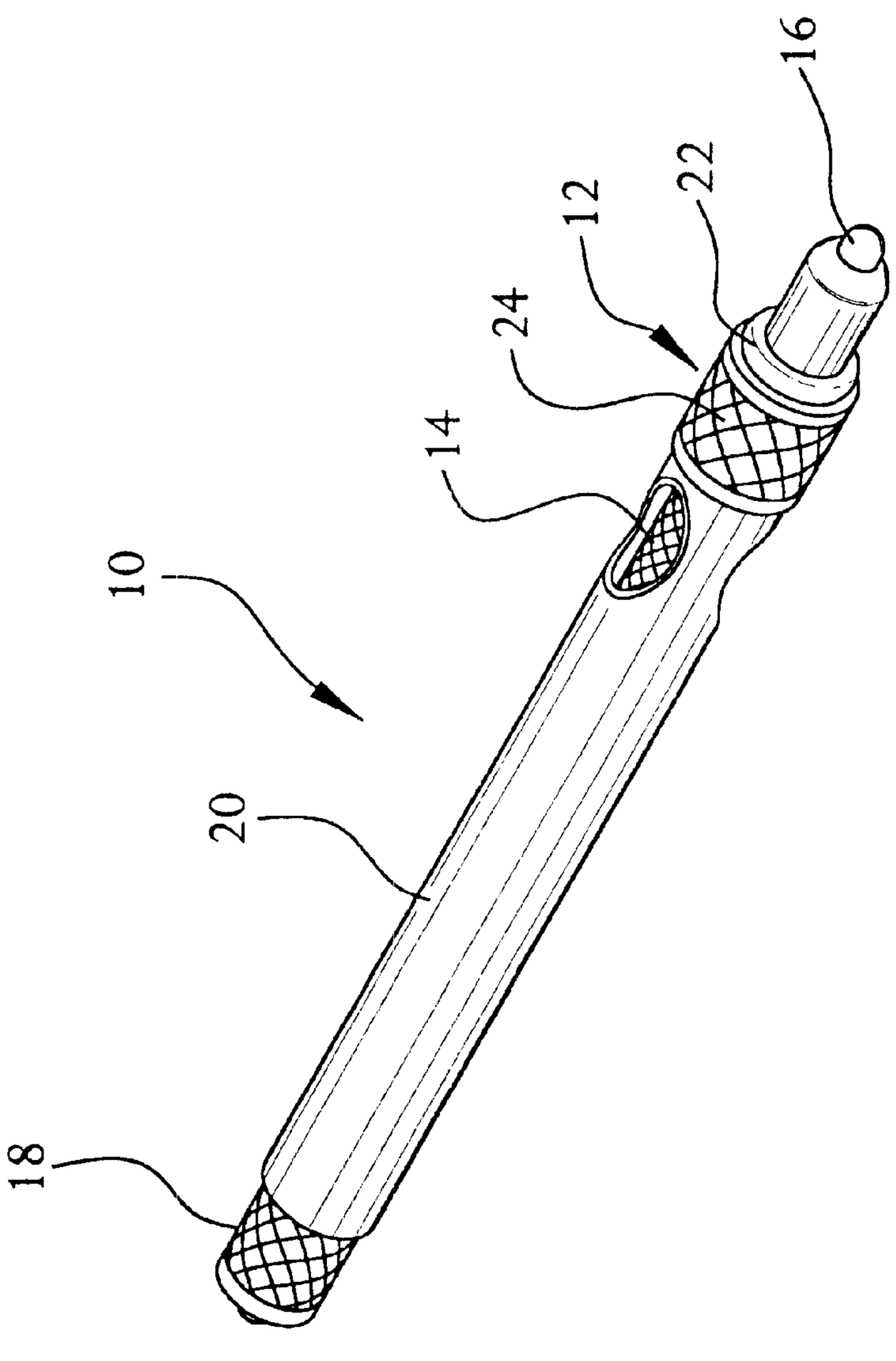


FIG. 1

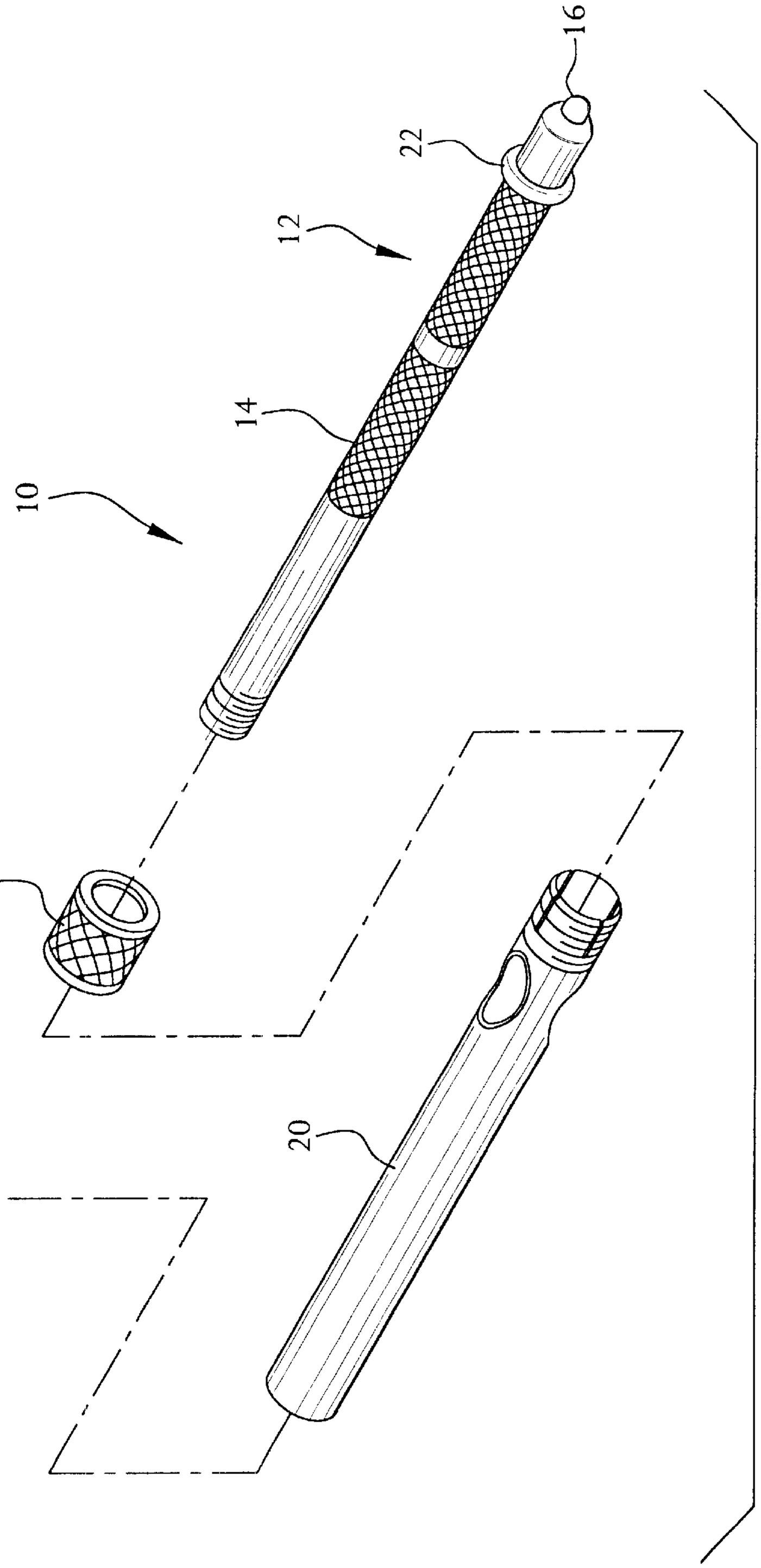


FIG. 2

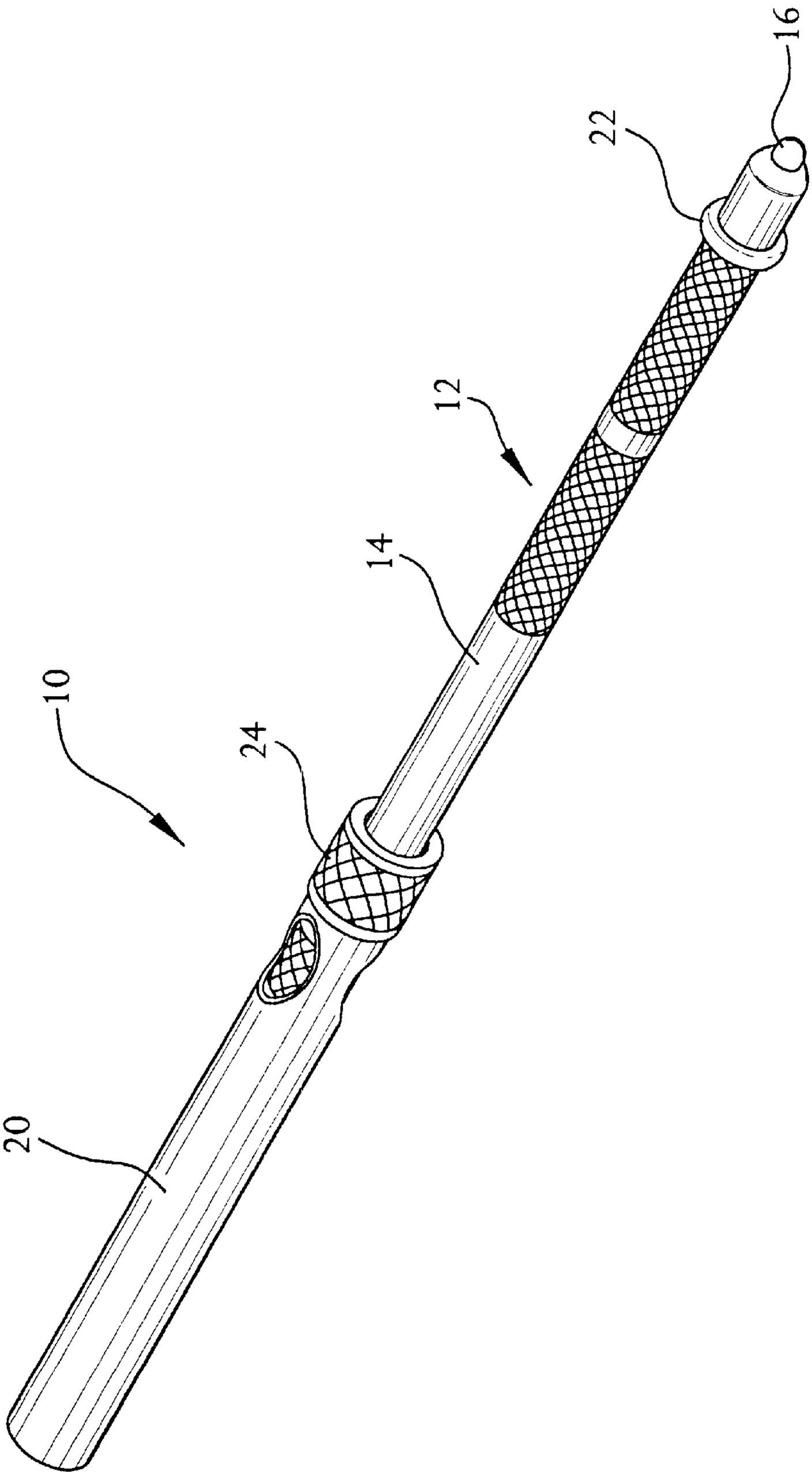


FIG. 3

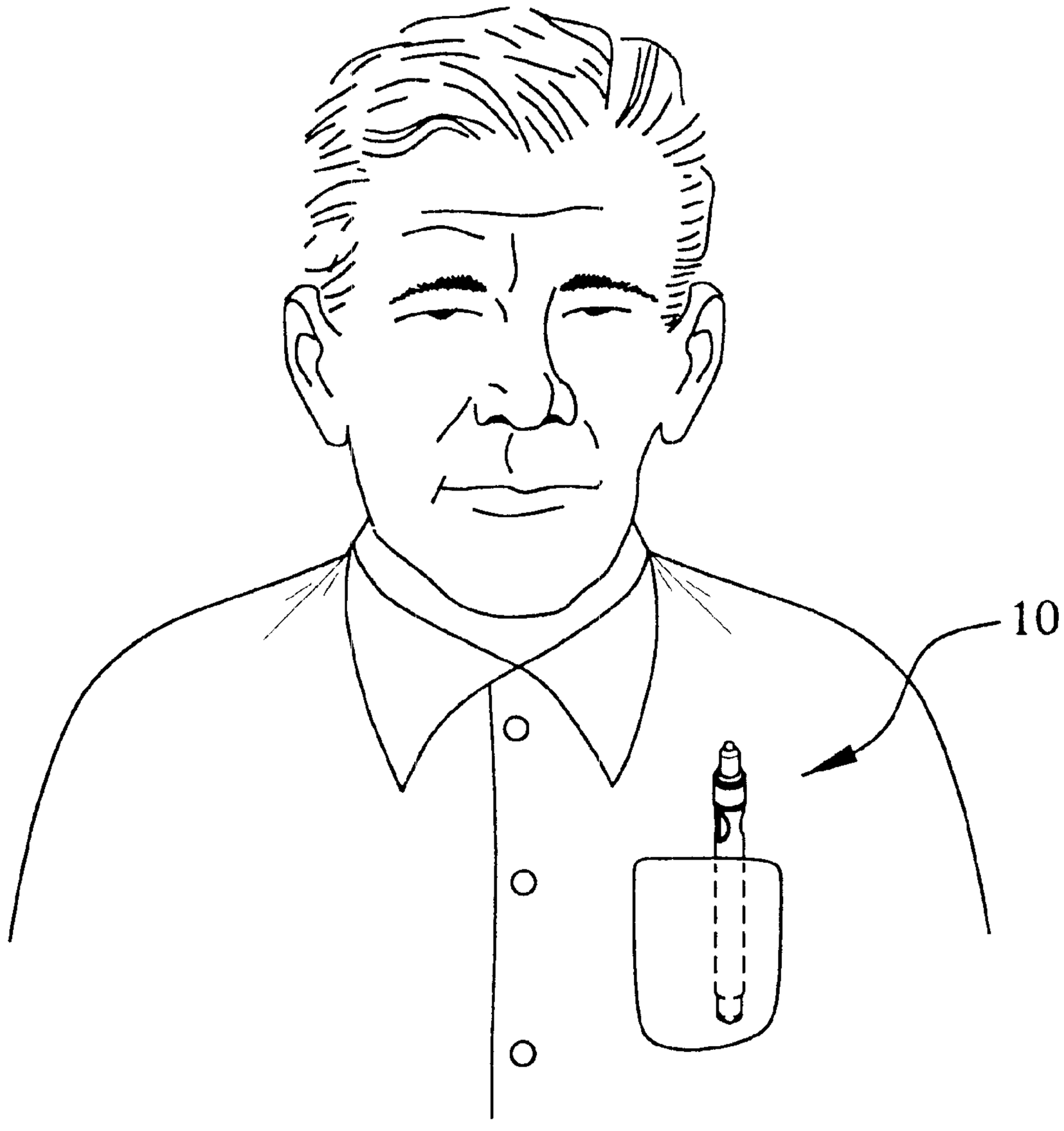


FIG. 4

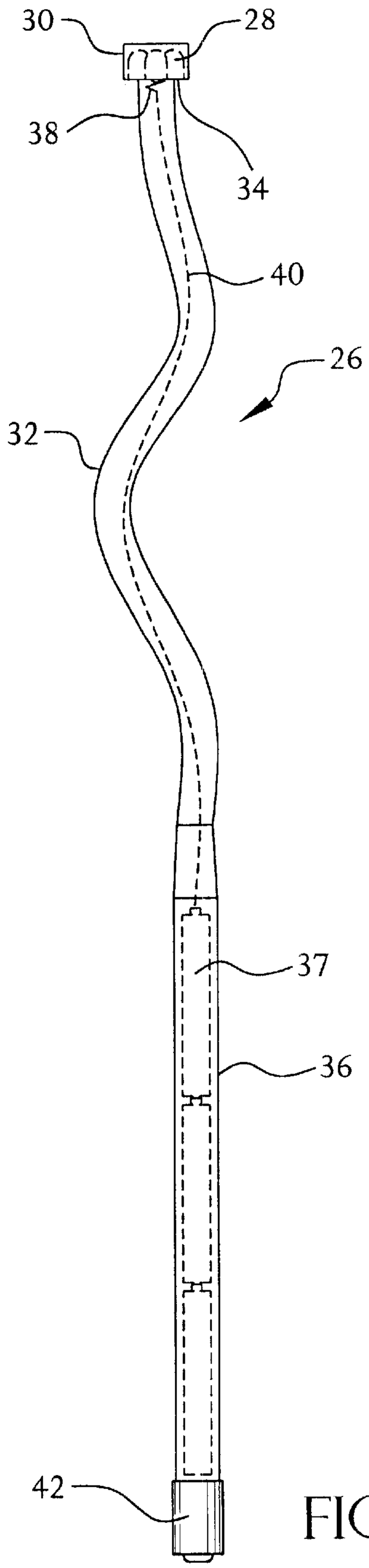


FIG. 5A

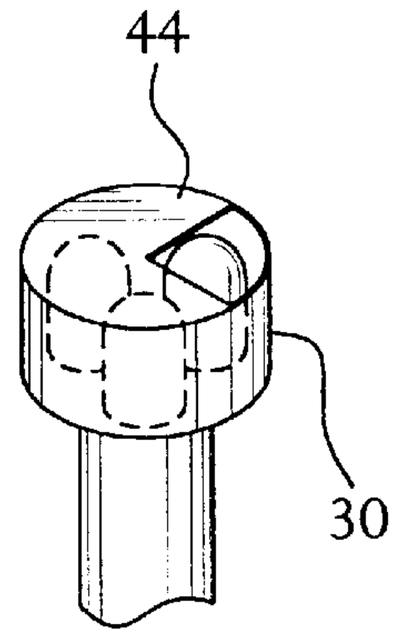


FIG. 5B

FIG. 6A

FIG. 6B

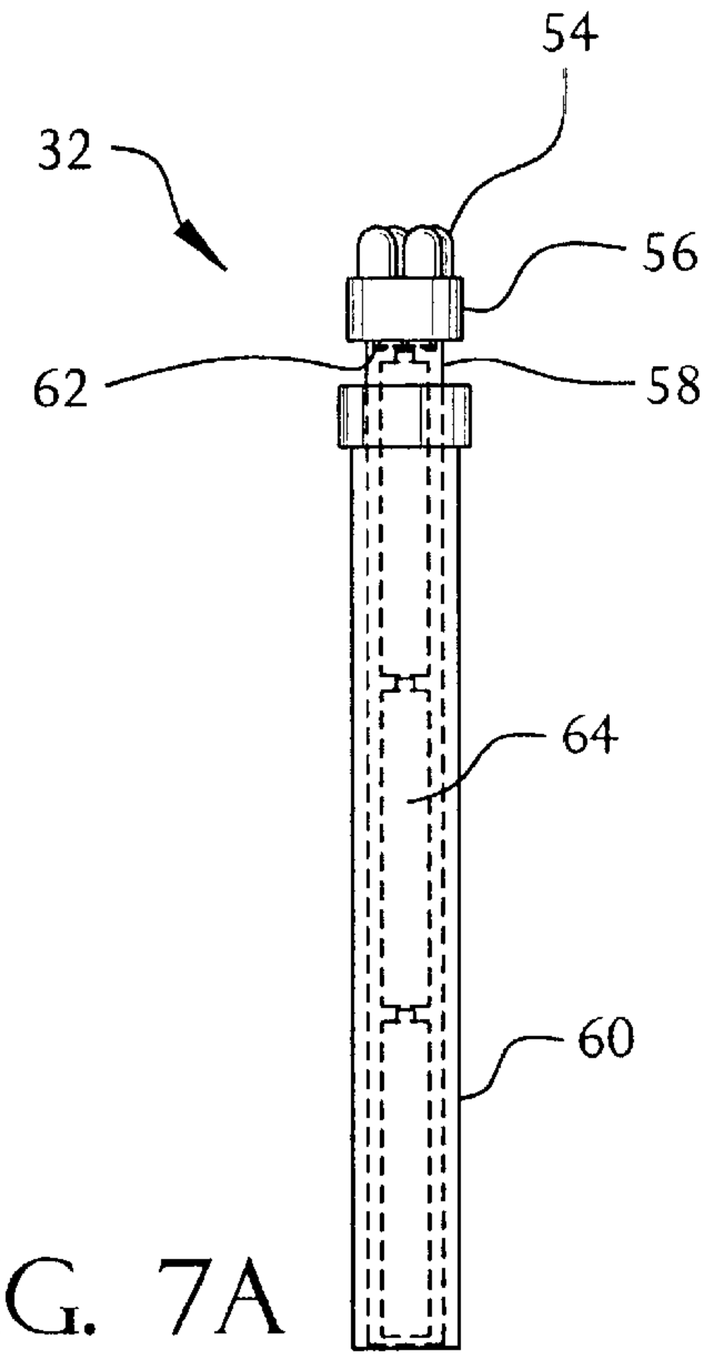


FIG. 7A

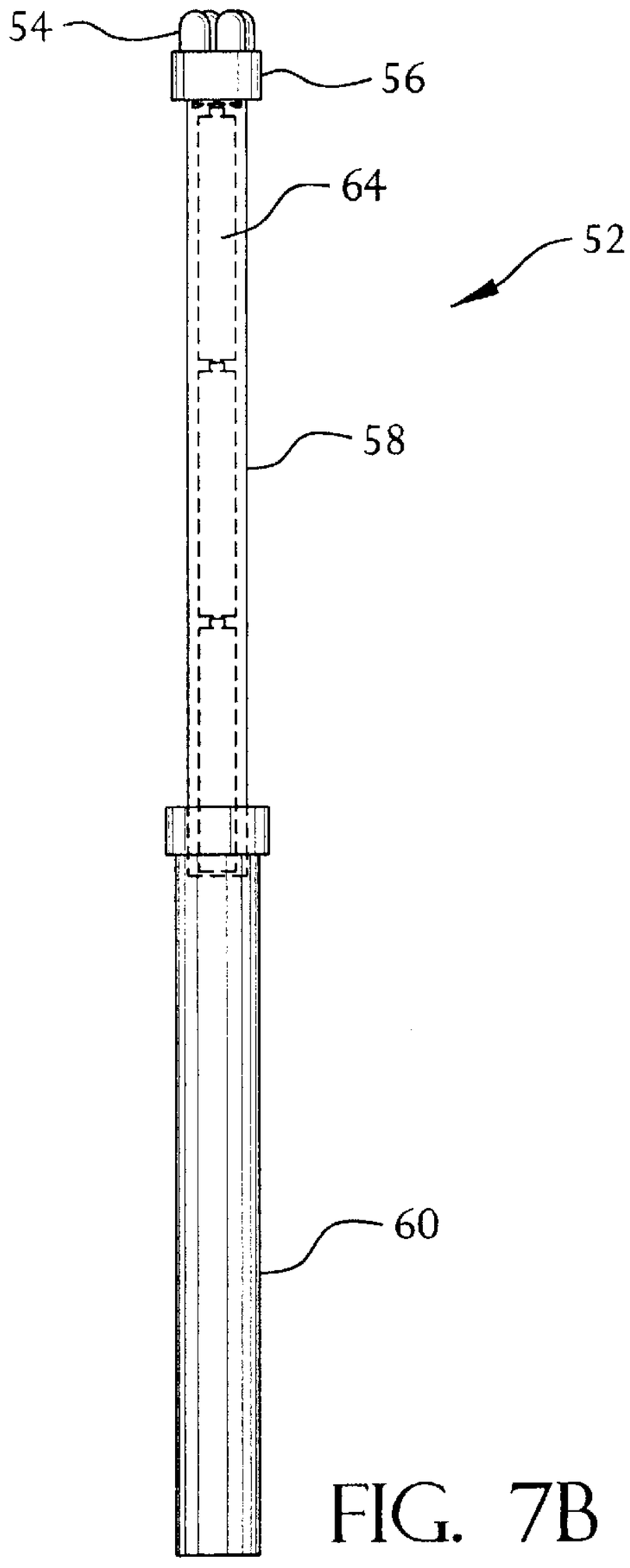


FIG. 7B

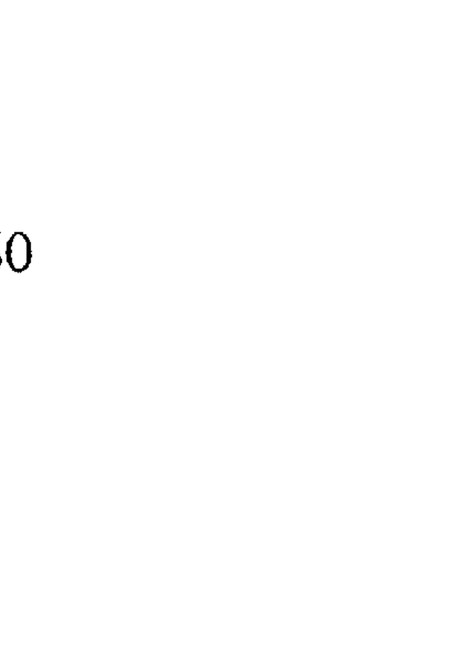


FIG. 7C

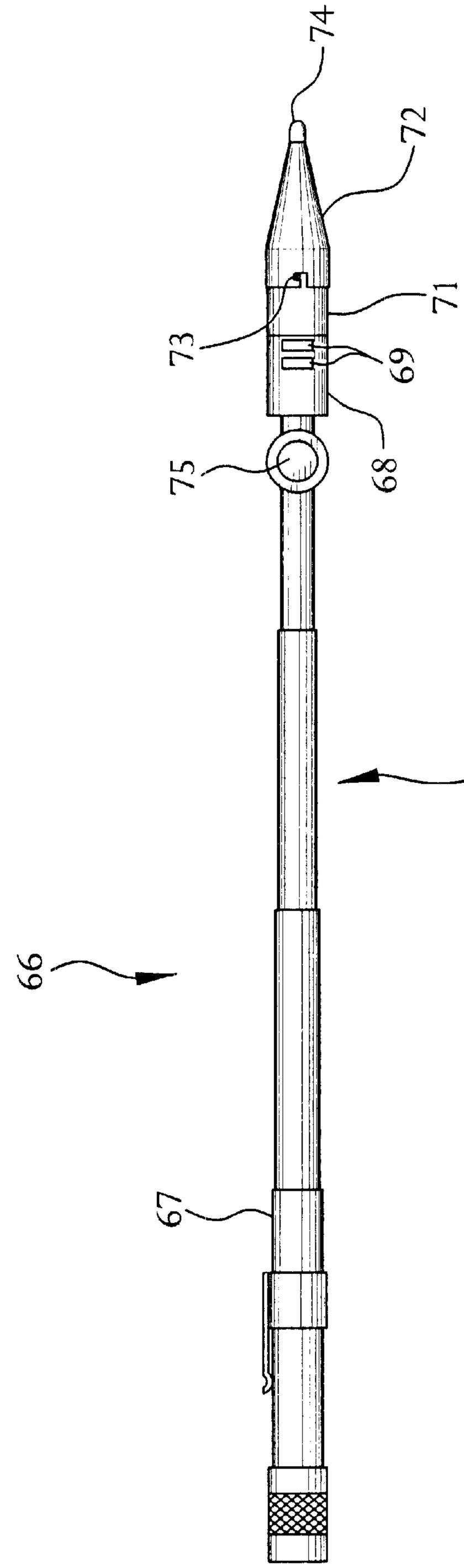


FIG. 8

PEN-SIZE LED INSPECTION LAMP FOR DETECTION OF FLUORESCENT MATERIAL

FIELD OF THE INVENTION

The invention relates to the general field of inspection lamps utilized for detection of fluorescent materials.

BACKGROUND OF THE INVENTION

Leak detection and surface flaw non-destructive testing techniques often use fluorescent dye additives or fluorescent penetrants. These techniques rely upon the unique physical property of various materials to fluoresce when excited by certain wavelengths of light.

Fluorescence is generally understood to be a property that enables some materials to absorb light energy and to radiate visible light at a longer wavelength than the absorbed light. According to generally accepted theory, electrons in fluorescent materials are excited upon being illuminated by light energy of a specific absorption band wavelength, and emit light energy in a longer wavelength response band as the electrons return to the unexcited or ground state. The specific excitation and response wavelengths are characteristics of the particular fluorescent materials.

The apparent brightness of a fluorescent material's luminescence is dependent on the wavelength and the intensity of the incident radiation. The excitation band generally has one or more peak wavelengths that will produce a greater response than incident light of the same intensity at an off-peak wavelength. Thus, a fluorescent material which has an excitation peak at a specific wavelength may exhibit a much reduced luminescence as the wavelength of incident light deviates from the excitation peak, and will lose the ability to fluoresce when the incident light does not provide enough energy within the excitation range.

For example, two commonly used fluorescent leak detection dyes are perylene-based fluorescent compounds and naphthalimide-based fluorescent compounds. Perylene dyes produce a yellow fluorescent response when exposed to incident radiation which includes the UV-A wavelength band of about 315 nm to about 400 nm, with a strong peak between about 340 to 375 nm. Naphthalimide dyes fluoresce green when exposed to incident radiation of visible violet/blue light in a range from about 400 nm to about 480 nm.

A fluorescent response is more visible when the intensity of other visible light is reduced, so that the fluorescent response is not masked or washed-out by other light. The various UV-A or Violet/Blue inspection lamps use several types of light sources and filtering to produce a light output in the excitation bands with little or no output light in the fluorescent response band. For example, a lamp having a high intensity incandescent light source with a narrow band UV (360–370 nm) absorption filter will emit light energy concentrated around the excitation peak of a perylene dye additive. An inspection lamp with a wider band UV/BLUE absorption filter centered at about 400 nm provides output in the UVA and visible violet/blue range, with the greatest intensity centered in the excitation band of a common naphthalimide dye compound. In the absorption filter lamps, however, the larger portion of light energy in the visible and infrared wavelengths is absorbed as heat in the filter.

A more efficient inspection lamp uses thin-film dichroic reflectance filter. A dichroic filter can be tailored to reflect back into the lamp only the range of visible wavelengths outside of the chosen excitation band, while passing the other wavelengths. Because the emitted light is not converted to heat in the dichroic filter, the lamp can be made considerably more compact than the lamps with absorption filters.

All of the above-described prior lamps use a broad spectrum light source, and thus require some type of filtering, whether absorption or dichroic, to transmit light in an excitation band while restricting light output in the visible fluorescent response band. In the present invention, however, the inspection lamp uses the narrow band electroluminescence of solid state lamps, specifically light-emitting diodes (hereinafter referred to as "LEDs") with glass envelopes that refract light to the tip of the envelope. LEDs have been known for many years, but until recent developments it has been difficult to obtain sufficiently high levels of luminous flux as would be required for an inspection lamp. This problem was particularly acute for LEDs emitting in the blue to UV bands, which produced much less lumens per watt than the red, yellow and green emitting LEDs. [See, Lighting Handbook, 8^{th} edition, Illuminating Engineers Society of North America, Chapter 6, figure 6.68(f)].

Recent developments in nitride semiconductor materials, particularly gallium nitride (GaN) based epitaxal structures, have provided more efficient LEDs that can produce sufficient lumens for an inspection lamp in the UV 360–390 nm range. For example, a GaN electroluminescent device as described in U.S. Pat. No. 5,898,185 has an emission peak at 380 nm. An LED emitting in the 360 nm–390 nm range would make a useful light source for detection of a perylene dye.

GaN alloys can produce other useful emission bands. The same patent describes a commercial GaInAlN LED that emits blue light at 460 nm. The light emission wavelengths of GaN LEDs can also be altered by phosphor films if desired. As described in the specification of the U.S. Pat. No. 5,898,185 patent, these GaN-based LEDs have high efficiencies, typically in the energy emitted/power-in range of 10%.

The invention uses these LED light sources in the form of a LED bulb in which the glass lens capsule directs light to the rounded tip of the capsule. This causes a narrow high intensity focus at the tip and a diverging beam emanating from the tip. The effect is having a highest light intensity at the capsule tip and a rapidly decreasing intensity as distance from the tip increases. Thus, while the intensity at close distances may be sufficient to excite a strong response from a fluorescent dye, the intensity at longer distances may not be enough to produce the fluorescent response.

An LED inspection lamp can be very small, in fact, it can be the size of a pen light powered by AAAA sized batteries. A current LED pen light, the STYLUSTM model with an "Ice Blue" emitting LED is only 0.38 inches in diameter and 6.60 inches in length and operates on three AAAA batteries with a run time of over 10 hours, yet it has sufficient blue light output to cause a fluorescent response in a naphthalimide-based leak detection additive from a distance of 18 inches in dark conditions. Even in daylight conditions, it can excite a naphthalimide dye to a bright response at one to six inches.

Although the narrow shape of the LED pen light is helpful in allowing the LED capsule to be inserted into narrow areas close to a suspected leak site, it is still restricted by its length. Furthermore, the metal handle and battery housing is inflexible. Both the short length and inflexibility can make it difficult or impossible to reach areas of potential leak sites,

such as lines and connectors in the circuit of an automobile air conditioner.

It would therefore be useful to provide an LED lamp that has a high intensity focus at the tip as well as an extendible handle so that the lamp may be inserted deeply into tight areas to bring the tip of the LED capsule close to the potential leak site to be investigated for fluorescent material. An extendible handle may alternatively be flexible to aid in insertion around obstructions. An alternative embodiment lamp may have two or more different color LEDs, such as violet and blue, which may be selectively used to detect more than one type of fluorescent material, or may have an LED and a white light bulb to select between general illumination and fluorescent detection.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided an inspection lamp for detecting fluorescent materials. The inspection lamp includes a housing, an extendible handle and at least one LED.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, there is shown in the drawings a form which is currently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is an exploded isometric view of an embodiment of the inspection lamp in accordance with the present invention.

FIG. **2** is an isometric view of an embodiment of the inspection lamp in accordance with the present invention.

FIG. **3** is an isometric view of an embodiment of the inspection lamp in accordance with the present invention.

FIG. **4** is an illustration of a human being with an embodiment of the inspection lamp in his shirt pocket.

FIG. **5**A is a side elevation view of an embodiment of the inspection lamp in accordance with the present invention.

FIG. **5**B is an isometric view of the lamp housing of an embodiment of the inspection lamp in accordance with the present invention.

FIG. **6**A is a side elevation view of an embodiment of the inspection lamp where the lamp is in the unextended position in accordance with the present invention.

FIG. **6**B is a side elevation view of an embodiment of the inspection lamp where the lamp is extended in accordance with the present invention.

FIG. **7**A is a side elevation view of an embodiment of the inspection lamp where the lamp is in the unextended position in accordance with the present invention.

FIG. **7**B is a side elevation view of an embodiment of the inspection lamp where the lamp is extended in accordance with the present invention.

FIG. **7**C is an isometric view of the lamp housing of an embodiment of the inspection lamp in accordance with the present invention.

FIG. **8** is a isometric view of an embodiment of the inspection lamp where the inspection lamp includes a telescoping handle.

DESCRIPTION OF THE INVENTION

FIGS. **1–4** show an embodiment of an inspection lamp **10** in accordance with the invention. This embodiment of inspection lamp **10** includes an LED pen light **12** having an aluminum housing **14**. In this embodiment, shown in FIG. **2**, a rear end of the housing is threaded while the front end includes an aperture for receiving a glass lens capsule **16**. The housing **14** is adapted to enclose the LED pen light's batteries, switch contacts and light source. The pen light **12** uses a blue LED as its light source. The glass lens capsule **16** of the LED extends out through the front end of the housing. An example of a suitable commercially available LED pen light of this type is the STYLUS3 "ICE BLUE" penlight by Streamlight®.

The bottom of the pen light housing **14** has a screw cap **18** that also serves as an ON/OFF switch by pressing the batteries into an electrical connection, either by tightening the screw cap or by pressing a momentary switch at the back of the cap.

A hollow extendible handle **20** is adapted to slidingly engage around the housing **14** of the LED pen light. The top end of the extendible handle is adapted to receive a locking mechanism **24** for locking the handle in a desired position relative to the housing, in effect extending the handle of the inspection lamp **10** to a desired length. In this embodiment, the top end of the handle is threaded and slotted, while the locking mechanism is a threaded collar. When the collar **24** is tightened to the bottom of the threads, it compresses the slotted tip of the handle and presses it against the pen light housing to keep the pen light from sliding within the handle. A stop ring **22** is provided around the pen light housing to prevent the collar from slipping off the front end of the pen light.

In FIG. **1**, the inspection lamp is shown locked in a fully retracted position. FIG. **3** shows the same lamp locked in a fully extended position. FIG. **4** shows the inspection lamp carried as a pen light inside a shirt pocket so as to illustrate the lamp's relative size.

The light from the LED is directed through the rounded tip of the glass lens capsule. Thus, the emitted light beam has its highest light intensity in a narrow beam at the tip of the glass capsule **16**, and the beam diverges as distance from the tip increases.

In FIGS. **5**A and **5**B, an alternative embodiment inspection lamp **26** uses three LEDs **28** inside a lamp housing **30**. The lamp housing **30** is attached to an extendible handle **26** having an upper flexible portion **32** and a lower rigid portion **36** of the inspection lamp. The upper flexible portion **32** includes a hollow cavity and can be adjusted and extended as desired. The upper flexible portion **32** can be folded onto the lower rigid portion **36** to shorten the length of the inspection lamp.

The underside of the lamp housing **34** includes electrical contacts **38** to connect the LEDs **28** to a conductor wire **40**. The wire **40** extends downward from the electrical contact **38** through the upper flexible portion **32** to connect with the batteries **37**. The lower rigid portion **36** includes a removable cap **42**. The removable cap **42** includes a metallic coil for completing the circuit in the typical fashion to power the LEDs **28**.

FIG. **5**B shows a closer view of the lamp housing **30**. The top side of the lamp housing includes a rotatable cover **44** with an aperture suitable for only one LED for selectively blocking the light from two of the LEDs, so that only the light from one LED is emitted from the inspection lamp at any one time. The lamp housing **30** may contain different LEDs **28** and may also include an incandescent lamp or other suitable source of white light.

For example, the lamp may contain three LEDs, one in each of ultraviolet, blue, and green. Depending on the

fluorescent dye being used, the cover can be rotated so that only the appropriate LED is emitted by the inspection lamp. For instance, if a perylene-based fluorescent compound is being used, the ultraviolet LED may be selected. When using a naphthalimide-based fluorescent compound, the blue LED may be selected.

Shown in FIGS. **6**A and **6**B is another embodiment where the pen-size inspection lamp has an extendible handle **46** which is at least part flexible. An upper flexible portion **48** is slidably engaged with the lower rigid portion **50**. The upper flexible portion **48** has an inner diameter greater than the outer diameter of the lower rigid portion **50**. FIG. **6**A shows the inspection lamp in a non-flexed and non-extended position. FIG. **6**B shows the inspection lamp fully extended and partially flexed.

FIGS. **7**A, **7**B, and **7**C show another embodiment of the present invention, in which the inspection lamp has four LEDs **54** attached to a lamp housing **56**. An incandescent lamp or other source of white light may substituted for one of the LEDs. The lamp housing is rotatably attached to an upper portion **58** of an extendible handle **52**. The extendible handle **52** comprises the upper portion **58** and a lower portion **60**. The upper portion **58** is slidably engaged with the lower portion **60**. The outer diameter of the upper portion **58** is less than the inner diameter of the lower portion **60**. The upper portion **58** and lower portion **60** include a hollow cavity as shown in FIGS. **7**A and **7**B. In a preferred embodiment, the hollow cavity of the upper portion **58** contains a power source. In the same embodiment, the power source is an internal power source comprising at least one battery **64**.

The underside of the lamp housing **56** includes a plurality of electrical contacts **62**. The number of electrical contacts **62** located at the underside of the lamp housing **56** corresponds to the number of LEDs and sources of white light **54** attached to the lamp housing **56**. As noted earlier, when working with leak detection dyes, certain LEDs work most efficiently in conjunction with certain fluorescent compounds. In one embodiment, three LEDs, ultraviolet, blue, and green, and one source of white light are attached to the lamp housing. In order to selectively illuminate a single LED or source of white light, the lamp housing **56** is rotated so as to cause the electrical contact of the desired LED or white light to contact the inspection lamp's source of power. For instance, if the green LED is to be emitted by the inspection lamp, the lamp housing **56** is rotated so as to cause the green LED's electrical contact to connect with the power source.

The embodiment of the present invention shown in FIGS. **7**A and **7**B may be extended to illuminate hard-to-reach areas. FIG. **7**B shows the inspection lamp fully extended.

Referring now to FIG. **8**, another embodiment of the present invention is shown in which the inspection lamp **66** includes an extendible handle **67** and a removable LED lamp assembly **72**. In this embodiment, the extendible handle **67** is comprised of a plurality of slidingly engaged cylinders **70** of sequentially reduced diameter to facilitate the handle's ability to extend and contract in a telescoping manner. The telescoping handle **67** may be comprised of any number of cylinders and those cylinders may be of any size or shape. For instance, the circular section cylinders may be replaced with hollow square cylinders. In FIG. **8**, the handle is shown in an extended position.

In one embodiment of the inspection lamp **66** shown in FIG. **8**, there is a battery housing **68** opposite the telescoping handle **67**. The battery housing **68** may include controls **69** for connecting the LED lamp assembly **72** to at least one battery and to have a threaded top (not shown) for releasably engaging a screw cap **71**. The battery housing **68** is configured to accept coinsized batteries (not shown) to provide electrical power to the LED lamp assembly **72**. The LED lamp assembly **72** is releasably attached to the screw cap **71**. In the depicted embodiment, the LED lamp assembly **72** may be locked in place with a locking mechanism, an example of which is shown in FIG. **8**, numeral **73**. The locking device **73** shown in FIG. **8** is simply shown as an example; those skilled in the art will realize that many arrangements capable of releasably locking the LED lamp assembly **72** to the screw cap **71** could be used.

In a preferred embodiment, the LED lamp assembly **72** includes an LED **74** with a wavelength band having a peak intensity below about 500 nm. It is important to note however, that the LED lamp assemblies **72** are interchangeable, and thus the lamp **66** may be configured with an LED having any wavelength band. Therefore, if it is desirable to utilize an LED of a particular color, the user may simply replace the LED lamp assembly **72** with an LED lamp assembly **72** having the color of choice. For instance, a user using the inspection lamp **66** with a LED lamp assembly **72** having a blue LED may find it desirable to use a LED lamp assembly **72** having a green LED. If so, the user may simply remove the LED lamp assembly **72** having a blue LED and replace it with a LED lamp assembly **72** having a green LED.

In other embodiments, where the LED lamp assembly **72** may include two or more LEDs, it is preferable if at least one LED has a wavelength band with a peak intensity below about 500 nm. In such an embodiment, the controls **69** are adapted to selectively illuminate at least one LED, as desired.

In a preferred embodiment, there is a hinge **75** located between the handle **70** and the housing **68**, as shown in FIG. **8**. In other embodiments, where a hinge is not present, housing **68** is simply attached to the telescoping handle **70**.

It is important to note that the various forms of extendible handles as well as the manner in which the various embodiments are able to emit a single LED or white light and are able to extend and flex is completely interchangeable. For example, the lamp housing **30** and cover **44** used for selectively emitting a single LED as shown in FIGS. **5**A and **5**B may be utilized with the upper **58** and lower **60** cylindrical portions shown in FIGS. **7**A and **7**B.

In other embodiments, aspects of the handle may include alternative means for extending the inspection lamp from a shorter configuration to a longer configuration. Such means may include, for example, a spring and release mechanism for causing the inspection lamp to quickly extend by activating the release of a spring-type mechanism or other device capable of causing the inspection lamp to quickly extend. A means for extending the inspection lamp may also be configured similar in operation to a typical jack knife that is folded in half and locked when not in use. Such a configuration could include a hinge, ball-joint or other suitable element for causing the lamp to be collapsed approximately in half. A configuration could also include a locking mechanism so that the lamp is locked into place when collapsed or folded, as well as a release mechanism for releasing the lock. The release could be employed with or without a spring-type mechanism.

The present invention may also be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be

made to the appended claims, rather than to the foregoing specification, as indicating the scope of the invention.

What is claimed is:

1. An inspection lamp for detecting refrigerant leaks from air-conditioning systems through illumination of fluorescent materials added to the refrigerant and lubricating oil, said inspection lamp comprising an LED pen light having a housing enclosing a power source and an LED, the housing having a rear end and a front end, with a glass lens capsule at the front end, said inspection lamp further comprising;

a hollow handle adapted to receive the pen light, whereby the pen light may be retracted into the handle or extended out of the handle; and

wherein the LED emits light within a wavelength band below about 500 nm.

2. An inspection lamp as in claim **1**, wherein the LED emits light within a wavelength band between about 315 nm and about 400 nm.

3. An inspection lamp as in claim **1**, wherein the LED emits light within a wavelength band between about 400 nm and about 480 nm .

4. An inspection lamp as in claim **1**, wherein the LED emits light within a wavelength band between about 360 nm and about 380 nm.

5. An inspection lamp as in claim **1**, wherein the handle is slidably engaged within the housing and has a threaded top portion adapted to receive a locking mechanism for locking the pen light at a desired extension out of the handle.

6. An inspection lamp for detecting refrigerant leaks from air-conditioning systems through illumination of fluorescent materials added to the refrigerant and lubricating oil, said inspection lamp comprising:

a lamp housing;

at least one LED located within the lamp housing and emitting light within a wavelength band below about 500 nm;

a handle having an upper flexible portion attached to the lamp housing and a lower portion;

wherein the flexible portion may be bent to fit into hard-to-reach areas of the air-conditioning system.

7. An inspection lamp as in claim **6**, wherein the flexible portion may be bent so as to shorten the length of the lamp.

8. An inspection lamp as in claim **6**, further comprising a plurality of LEDs within the lamp housing.

9. An inspection lamp as in claim **8**, wherein the plurality of LEDs comprises at least one LED emitting light within a wavelength band between about 315 nm to about 400 nm.

10. An inspection lamp as in claim **8**, wherein the plurality of LEDs comprises at least one LED emitting light within a wavelength band between about 400 nm to about 480 nm.

11. An inspection lamp as in claim **6**, further comprising a light-impervious cover for selectively blocking the light emitted from the at least one LED.

12. An inspection lamp as in claim **11**, wherein the light-impervious cover rotatably engages with the top of the lamp housing.

13. An inspection lamp as in claim **12**, wherein at least a portion of the light-impervious cover is transparent or open.

14. An inspection lamp as in claim **6**, further comprising at least one source of white light.

15. An inspection lamp as in claim **14**, further comprising a light-impervious cover for selectively blocking the light emitted from the at least one LED and the at least one source of white light, as desired.

16. An inspection lamp for detecting refrigerant leaks from air-conditioning systems through illumination of fluorescent materials added to the refrigerant and lubricating oil, said inspection lamp comprising:

a lamp housing;

a plurality of LEDs enclosed within the lamp housing, at least one of which emitting light within a wavelength band below about 500 nm; and

an extendible handle attached to the lamp housing.

17. An inspection lamp as in claim **16**, wherein the plurality of LEDs comprises at least one LED emitting light within a wavelength band between about 315 nm to about 400 nm.

18. An inspection lamp as in claim **16**, wherein the plurality of LEDs comprises at least one LED emitting light within a wavelength band between about 400 nm to about 480 nm.

19. An inspection lamp as in claim **18**, further comprising a plurality of electrical contacts, wherein at least one electrical contact is attached to each LED and the lamp housing is rotatably engaged with the handle such that rotating the lamp housing selects an LED to be connected to a power source and thereby illuminated.

20. An inspection lamp as in claim **19**, further comprising at least one source of white light.

21. An inspection lamp as in claim **20**, further comprising a plurality of electrical contacts, wherein at least one electrical contact is attached to each LED and to each source of white light, and wherein the lamp housing is rotatably engaged with the handle such that rotating the lamp housing selects an LED or source of white light to be selectively connected to a power source and thereby illuminated.

22. An LED inspection lamp for detecting refrigerant leaks from air-conditioning systems through illumination of fluorescent materials added to the refrigerant and lubricating oil, said inspection lamp comprising:

extendable and retractable handle having a grip section and telescoping sections adapted to be pulled out to extend the handle and pushed in to retract the handle,

a battery housing containing a battery, the battery housing being attached at one end thereof to the telescoping section that is furthest from the grip section when the handle is extended; and

an LED lamp assembly connected to the battery housing and containing an LED.

23. An inspection lamp as in claim **22**, further comprising the lamp having controls to selectively connect the LED to the battery.

24. An inspection lamp as in claim **23**, wherein the lamp assembly contains a plurality of LEDs.

25. An inspection lamp as in claim **24**, further comprising the lamp having controls to selectively connect an LED to the battery.

26. An inspection lamp as in claim **22**, wherein the LED emits light within a wavelength band between about 315 nm to about 400 nm.

27. An inspection lamp as in claim **22**, wherein the LED emits light within a wavelength band between 400 nm to about 480 nm.

28. An inspection lamp as in claim **22**, wherein the LED lamp assembly is removable and a first LED lamp assembly having an LED emitting light within a first wavelength band is interchangeable with a second LED lamp assembly having an LED emitting light within a different wavelength band.

29. An inspection lamp as in claim **22**, further comprising a hinge located between the grip end of the handle and the LED lamp assembly.

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